OPTIMIZATION DESIGN OF THE RFQ TRAPEZOIDAL ELECTRODE

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(1) Introduction

1.1 General method for RF cavity design

- Generate the basic parameters of acceleration cell.
- Optimization of the cavity structure.
- Study of the beam dynamics with the field from RF analysis.

Some time consuming iterations are necessary to obtain reasonable solution.

1.2 Code for design of periodic acceleration structure

- Based on VBA and CST EM Studio.
- The 3-m-long section electrode with trapezoidal modulation of a deuteron beam RFQ has been designed by this code.

1.3 Advantages

- Implement repetitive work by code.
- Open-ended and extensible.
- Can be used to design other periodic acceleration structures.
- Can be used for special structures.

(2) The Design of Deuteron Beam RFQ

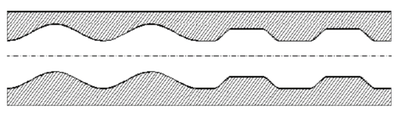
Table.1: Main parameters for deuteron beam RFQ.

Parameter/Feature	Value
Input Energy	20 keV/u
Output Energy	1.7 MeV/u
Frequency	162.5 MHz
Vane Voltage	65 kV
Average Radius	4.8 mm
Length	5.25 m
Bunching	Internal

Figure 1: 3D model of the deuteron beam RFQ.

Five segments.
The last 3.25-m-long section will use trapezoidal modulation.

(3) The Design of RFQ Electrode with Trapezoidal Modulation



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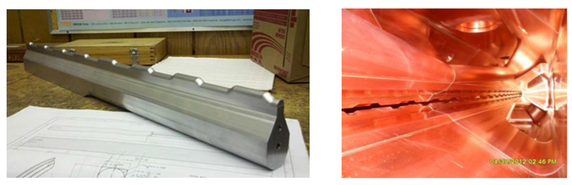


2012 Argonne [2]

[1] O. K. Belyaev et al, Proceedings of the 20th Linac Conference, Monterey, California, page 259.
[2] P. N. Ostroumov et al., Phys. Rev. ST Accel. Beams 15, 110101 (2012).

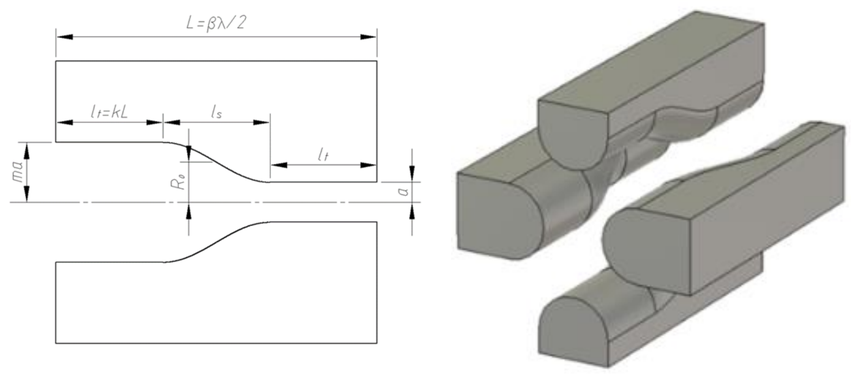


Figure 2: The longitudinal section of one cell trapezoidal modulation RFQ electrode and the 3D model.

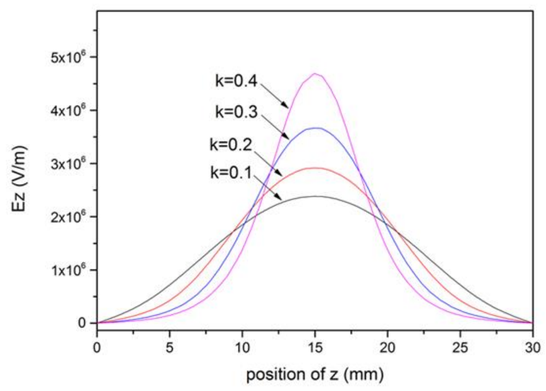


Figure 3: The axial component of the electrostatic field for different proportion of the flat part.

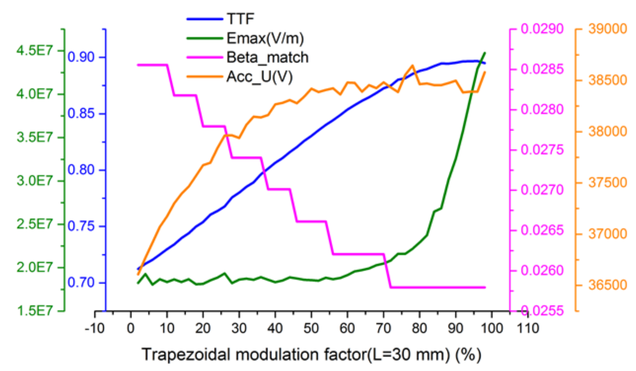


Figure 4: Parameter sweep of trapezoidal modulation factor (L=30 mm).

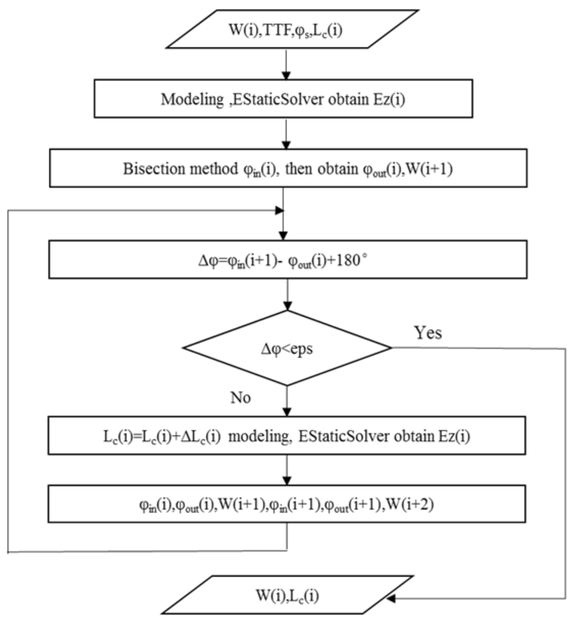
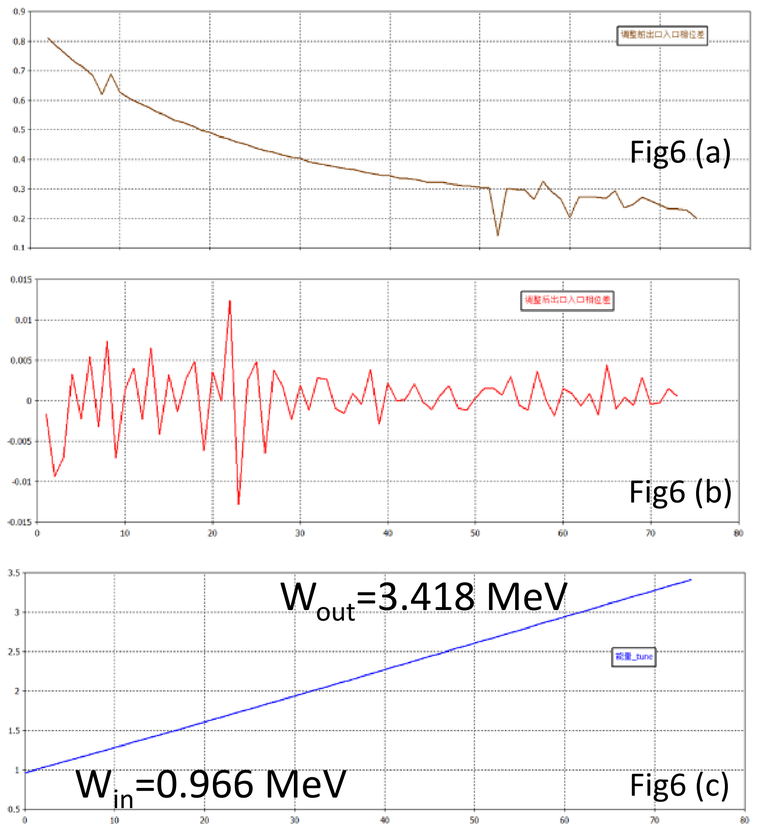


Figure 5: The flow chart of the code to design the longitudinal structure of RFQ electrode.

$$F(\varphi_{in}) = \tan^{-1}\frac{\left[\int_0^L qE_z(s)\cdot\sin\left[\varphi_{in}+\frac{\omega_{rf}}{c}\int_0^s\frac{ds'}{\beta_z(s')}\right]\cdot ds\right]}{\left[\int_0^L qE_z(s)\cdot\cos\left[\varphi_{in}+\frac{\omega_{rf}}{c}\int_0^s\frac{ds'}{\beta_z(s')}\right]\cdot ds\right]}-\varphi_s$$



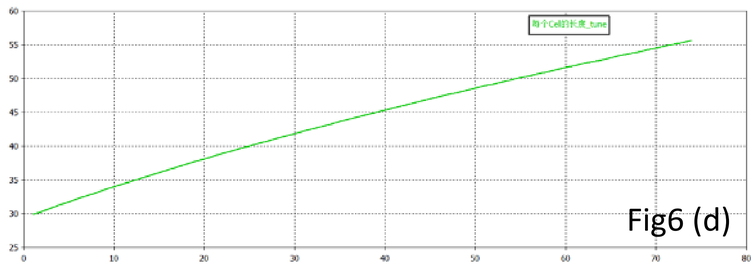
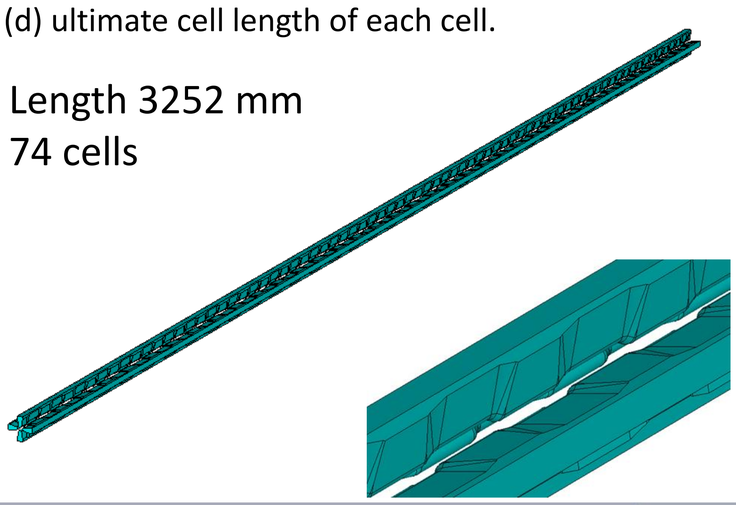


Figure 6: (a) phase difference between cells before adjustment (b) phase difference between cells after adjustment (c) energy at the exit of each cell (d) ultimate cell length of each cell.

Length 3252 mm
74 cells



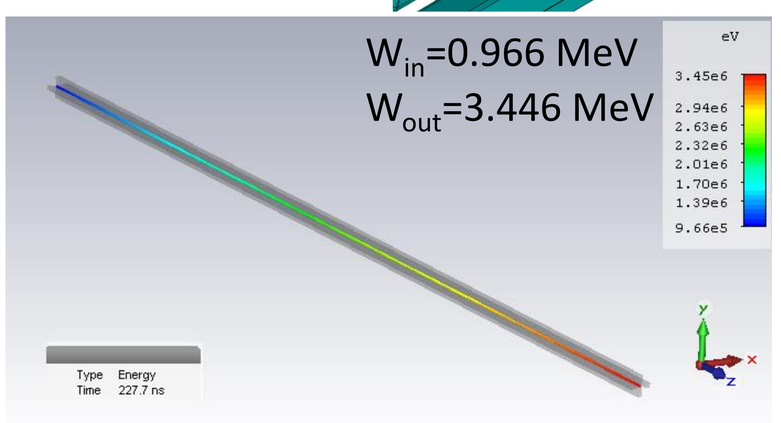


Figure 7: 3D model of trapezoidal modulation RFQ electrode and the result of beam dynamics simulation.

(4) Fabrication Test

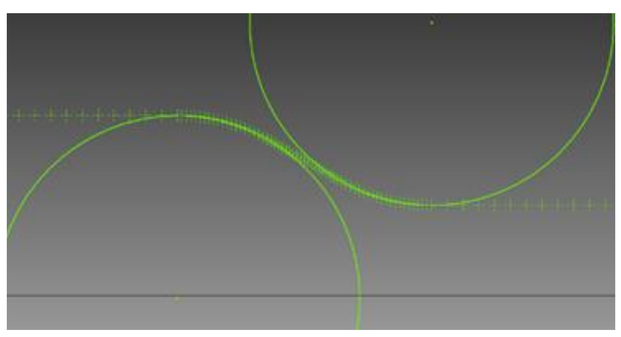


Figure 8: Substitute the sinusoidal transition part by two arcs and their internal common tangent.

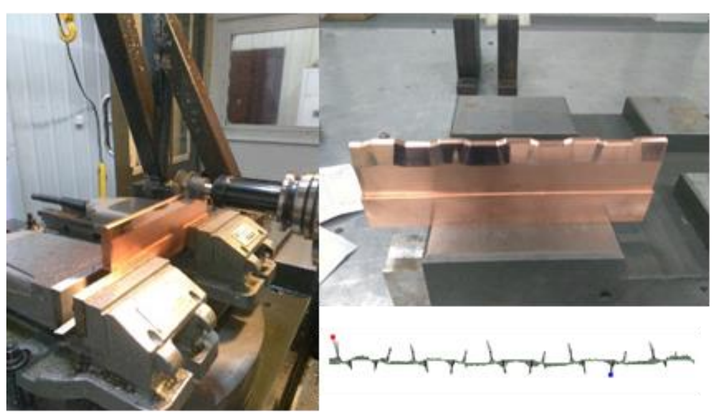


Figure 9: Fabrication and measurement of the trapezoidal modulation RFQ electrode.